KROHNE

Operating Instructions

OPTISWITCH 3100 C
with two-wire output

- Variable area flowmeters
- Vortex flowmeters
- Flow controllers
- Electromagnetic flowmeters
- Ultrasonic flowmeters
- Mass flowmeters
- **Level measuring instruments**
- Communications engineering
- Engineering systems & solutions
- Switches, counters, displays and recorders
- Heat metering
- Pressure and temperature

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Supplementary operating instructions manuals

Information:
OPTISWITCH 3100 C is available in different versions. Depending on the selected version, supplementary operating instructions manuals will also be included in the delivery. The supplementary operating instructions manuals are listed in section "*Product description*".

Operating instructions manuals for accessories and replacement parts

Tip:
To ensure reliable use and operation of your OPTISWITCH 3100 C we offer accessories and replacement parts. The corresponding operating instructions manuals are:

- Operating instructions manual "*Oscillator*"

1 About this document

1.1 Function

This operating instructions manual has all the information you need for quick setup and safe operation. Please read this manual before you start setup.

1.2 Target group

This operating instructions manual is directed to trained personnel. The contents of this manual should be made available to these personnel and put into practice by them.

1.3 Symbolism used

Information, tip, note
This symbol indicates helpful additional information.

Caution, warning, danger
This symbol informs you of a dangerous situation that could occur. Ignoring this cautionary note can impair the person and/or the instrument.

Ex applications
This symbol indicates special instructions for Ex applications.

● **List**
The dot set in front indicates a list with no implied sequence.

→ **Action**
This arrow indicates a single action.

1 **Sequence**
Numbers set in front indicate successive steps in a procedure.

2 For your safety

2.1 Authorised personnel

All operations described in this operating instructions manual must be carried out only by trained, specialist personnel authorised by the operator. For safety and warranty reasons, any internal work on the instruments must be carried out only by personnel authorised by the manufacturer.

2.2 Appropriate use

OPTISWITCH 3100 C is a sensor for level detection.

Detailed information on the application range of OPTISWITCH 3100 C is available in chapter "*Product description*".

2.3 Warning about misuse

Inappropriate or incorrect use of the instrument can give rise to application-specific hazards, e.g. vessel overfill or damage to system components through incorrect mounting or adjustment.

2.4 General safety instructions

OPTISWITCH 3100 C is a high-tech instrument requiring the strict observance of standard regulations and guidelines. The user must take note of the safety instructions in this operating instructions manual, the country-specific installation standards (e.g. the VDE regulations in Germany) as well as all prevailing safety regulations and accident prevention rules.

2.5 CE conformity

OPTISWITCH 3100 C is in CE conformity with EMC (89/336/EWG), fulfils the NAMUR recommendation NE 21 and is in CE conformity with NSR (73/23/EWG).

Conformity has been judged acc. to the following standards:

- EMC:
  - Emission EN 61326: 1997 (class B)
  - Susceptibility EN 61326: 1997/A1: 1998
- LVD: EN 61010-1: 2001

2.6 SIL conformity

OPTISWITCH 3100 C fulfills the requirements for functional safety acc. to IEC 61508. You will find further information in chapter "Functional safety".

2.7 Safety information for Ex areas

Please note the Ex-specific safety information for installation and operation in Ex areas. These safety instructions are part of the operating instructions manual and come with the Ex-approved instruments.

3 Product description

3.1 Configuration

Scope of delivery

The scope of delivery encompasses:

- OPTISWITCH 3100 C level sensor
- Documentation
  - this operating instructions manual
  - Supplementary instructions manual *"Plug connector for level sensors"* - optional
  - Ex specific safety instructions (with Ex versions), if necessary further certificates

Components

OPTISWITCH 3100 C consists of the following components:

- Housing cover
- Housing with electronics
- process fitting with tuning fork

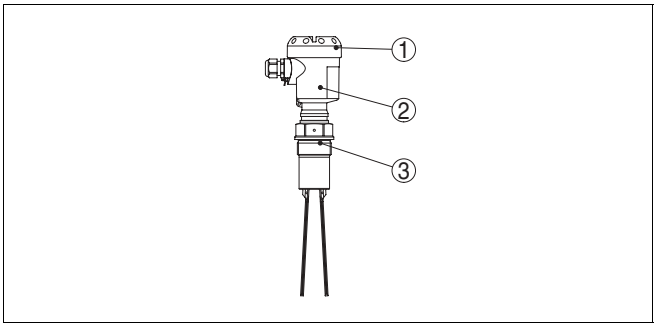

Fig. 1: OPTISWITCH 3100 C - with plastic housing
1 Housing cover
2 Housing with electronics
3 Process fitting

3.2 Principle of operation

Area of application

OPTISWITCH 3100 C is a level sensor with tuning fork for level detection.

It is designed for industrial use in all areas of process technology and is preferably used for bulk solids.

Typical applications are overfill and dry run protection. Thanks to its simple and robust measuring system, OPTISWITCH 3100 C is virtually unaffected by the chemical and physical properties of the solid.

It functions even when exposed to strong external vibration or changing products.

Solid detection in water
If OPTISWITCH 3100 C was ordered for solids detection in water, the tuning fork is set to the density of water. In air or when immersed in water (density: 1 g/cm³ / 0.036 lbs/in), OPTISWITCH 3100 C signals "uncovered". Only when the vibrating element is also covered with solids (e.g. sand, sludge, gravel etc.) will the sensor signal "covered".

Fault monitoring
The electronics of OPTISWITCH 3100 C continuously monitors the following criteria:

- Correct vibrating frequency
- Line break to the piezo drive

If one of these faults is detected, the electronics signals it via a defined current to the signal conditioning instrument. The connection cable to the vibrating element is also monitored.

Physical principle

The tuning fork is piezoelectrically energised and vibrates at its mechanical resonance frequency of approx. 150 Hz. When the tuning fork is submerged in the product, the vibration amplitude changes. This change is detected by the integrated oscillator and converted into a switching command.

Power supply

Depending on your requirements, OPTISWITCH 3100 C with two-wire electronics can be connected to different signal conditioning instruments. Compatible signal conditioning instruments are listed under Technical data.

The exact range of the voltage supply is specified in the Technical data in the Supplement.

3.3 Adjustment

With the factory setting, products with a density of >0.02 g/cm³ (>0.0008 lbs/in³) can be measured. It is possible to adapt the instrument for products with lower density >0.008 g/cm³ (>0.0003 lbs/in³).

On the electronics module you will find the following indicating and adjustment elements:

- signal lamp for indication of the switching condition (green/red)
- potentiometer for adaptation to the product density
- mode switch for selection of the output current

3.4 Storage and transport

Packaging

Your instrument was protected by packaging during transport. Its capacity to handle normal loads during transport is assured by a test acc. to DIN 55439.

The packaging of standard instruments consists of environment-friendly, recyclable cardboard. In addition, the sensor is provided with a protective cover of cardboard. For special versions PE foam or PE foil is also used. Dispose of the packaging material via specialised recycling companies.

Storage and transport temperature

- Storage and transport temperature see "Supplement - Technical data - Ambient conditions"
- Relative humidity 20 ... 85 %

4 Mounting

4.1 General instructions

Switching point

In general, OPTISWITCH 3100 C can be mounted in any position. The instrument must be mounted in such a way that the vibrating element is at the height of the requested switching point.

Moisture

Use the recommended cable (see chapter "*Connecting to power supply*") and tighten the cable gland.

You can give your OPTISWITCH 3100 C additional protection against moisture penetration by leading the connection cable downward in front of the cable entry. Rain and condensation water can thus drain off. This applies mainly to mounting outdoors, in areas where moisture is expected (e.g. by cleaning processes) or on cooled or heated vessels.

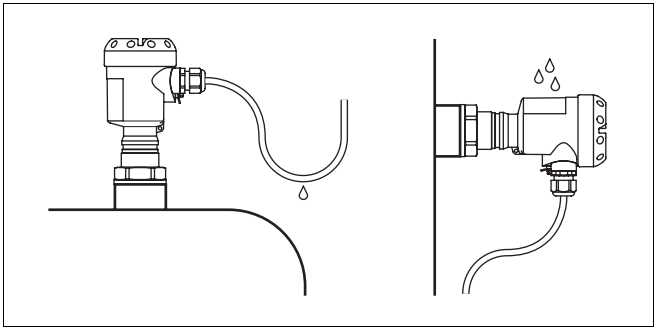

Fig. 2: Measures against moisture penetration

Transport

Do not hold OPTISWITCH 3100 C on the vibrating element. Especially with flange and tube versions, the sensor can be damaged by the weight of the instrument.

Remove the protective cover just before mounting.

Pressure/Vacuum

The process fitting must be sealed if there is gauge or low pressure in the vessel. Before use, check if the seal material is resistant against the measured product and the process temperature.

Handling

The vibrating level switch is a measuring instrument and must be treated accordingly. Bending the vibrating element will destroy the instrument.

Warning:
The housing must not be used to screw the instrument in! Applying tightening force on the housing can damage its internal mechanical parts.

To screw in, use the hexagon above the thread.

4.2 Mounting information

Socket

The vibrating element should protrude into the vessel to avoid buildup. For that reason, avoid using mounting bosses for flanges and screwed fittings. This applies particularly to use with adhesive products.

Filling opening

Install the instrument in such a way that the tuning fork does not protrude directly into the filling stream. Should such an installation location be necessary, mount a suitable baffle above or in front of the tuning fork.

If such an installation location should be necessary, mount a suitable protective sheet above or in front of the vibrating element - see illustration a.).

In abrasive solids, mounting acc. to illustration b. has proven. A spout forms in the concave protective sheet preventing wear of the protective sheet.

Horizontal installation

To achieve a very precise switching point, you can install OPTISWITCH 3100 C horizontally. However, if the switching point can have a tolerance of a few centimeters, we recommend mounting OPTISWITCH 3100 C approx. 20° inclined to the vessel bottom to avoid buildup.

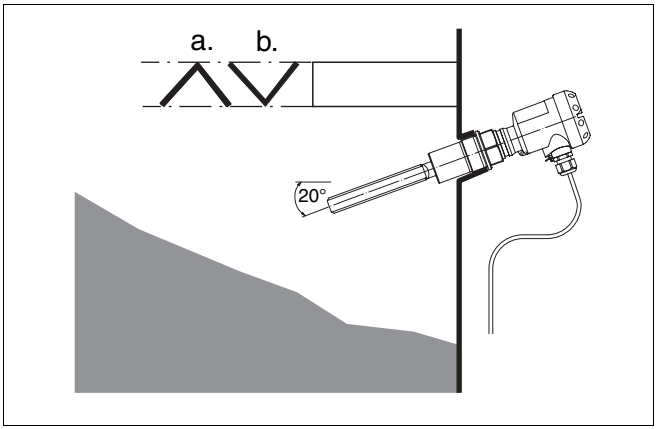

Fig. 3: Horizontal installation
a Protective sheet
b Concave protective sheet for abrasive solids

Inflowing material

If OPTISWITCH 3100 C is mounted in the filling stream, unwanted switching signals can be generated. Mount OPTISWITCH 3100 C at a location in the vessel where no disturbing influence from e.g. filling openings, agitators, etc. can occur.

Flow

To minimise flow resistance caused by the tuning fork, OPTISWITCH 3100 C should be mounted in such a way that the surfaces of the fork are parallel to the product movement.

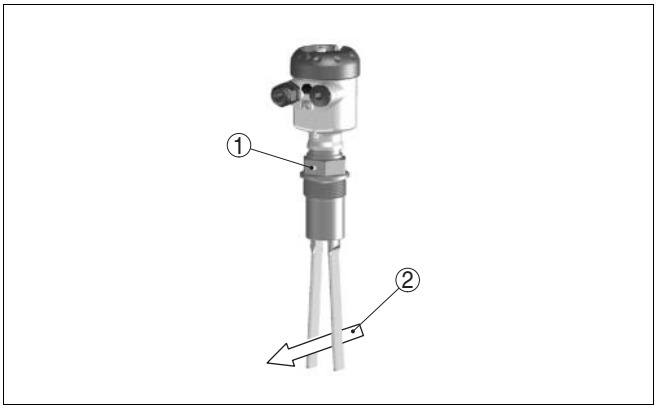

Fig. 4: Orientation of the tuning fork in case of flow
1 Marking with screwed version
2 Direction of flow

Adhesive products

In case of horizontal mounting in adhesive products, the surfaces of the tuning fork should be vertical in order to reduce buildup on the tuning fork. On the screwed version you will find a marking on the hexagon. With this, you can check the position of the tuning fork when screwing it in. When the hexagon touches the seal, the thread can be still turned by approx. half a turn. This is sufficient to reach the recommended installation position.

With flange versions, the fork is directed to the flange holes.

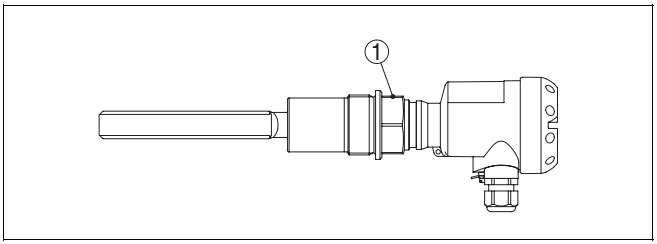

Fig. 5: Vertical installation - marking
1 Marking on top with screwed version

Baffle protection against falling rocks

In applications such as grit chambers or settling basins for coarse sediments, the vibrating element must be protected against damage with a suitable baffle.

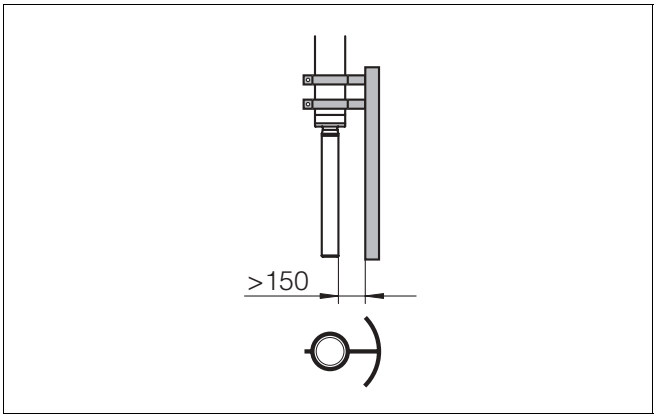

Fig. 6: Baffle protection against damages

5 Connecting to power supply

5.1 Preparing the connection

Note safety instructions

Always observe the following safety instructions:

- Connect only in the complete absence of line voltage

Take note of safety instructions for Ex applications

In hazardous areas you should take note of the appropriate regulations, conformity and type approval certificates of the sensors and power supply units.

Select power supply

Connect the power supply acc. to the following diagrams. Take note of the general installation regulations. As a rule, connect OPTISWITCH 3100 C to vessel ground (PA), or in case of plastic vessels, to the next ground potential. On the side of the instrument housing there is a ground terminal between the cable entries. This connection serves to drain off electrostatic charges. In Ex applications, the installation regulations for hazardous areas must be given priority.

The data for power supply are stated in the Technical data in the Supplement.

Select connection cable

OPTISWITCH 3100 C is connected with standard cable with round cross-section. An outer cable diameter of 5 ... 9 mm (0.2 ... 0.35 in) ensures the seal effect of the cable entry.

If cable with a different diameter or wire cross section is used, exchange the seal or use an appropriate cable connection.

In hazardous areas, only use approved cable connections for OPTISWITCH 3100 C.

Select connection cable for Ex applications

Take note of the corresponding installation regulations for Ex applications.

5.2 Connection procedure

With Ex instruments, the housing cover may only be opened if there is no explosive atmosphere present.

Proceed as follows:

1 Unscrew the housing cover

2 Loosen compression nut of the cable entry

3 Remove approx. 10 cm (4 in) of the cable mantle, strip approx. 1 cm (0.4 in) insulation from the ends of the individual wires

4 Insert the cable into the sensor through the cable entry

5 Lift the opening levers of the terminals with a screwdriver (see following illustration)

6 Insert the wire ends into the open terminals according to the wiring plan

7 Press down the opening levers of the terminals, you will hear the terminal spring closing

8 Check the hold of the wires in the terminals by lightly pulling on them

9 Tighten the compression nut of the cable entry, the seal ring must completely encircle the cable

10 Screw the housing cover back on

The electrical connection is finished.

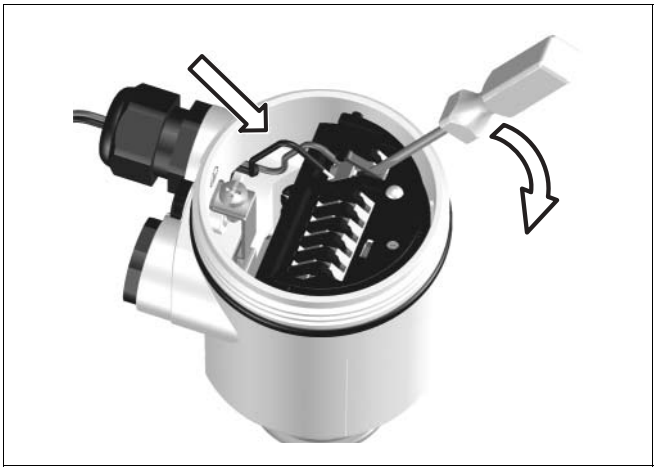

Fig. 7: Connection steps 5 and 6

5.3 Wiring plans, single chamber housing

The following illustrations apply to the non-Ex as well as to the EEx d version.

Housing overview

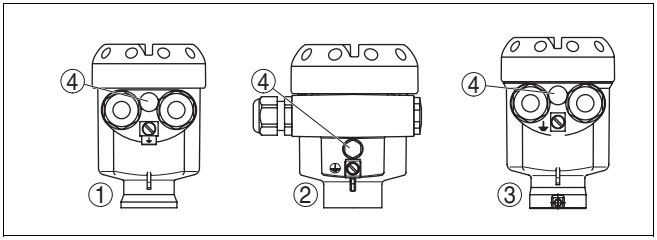

Fig. 8: Material versions, single chamber housing
1 Plastic (not with EEx d)
2 Aluminium
3 Stainless steel (not with EEx d)
4 Filter element for pressure compensation (not with EEx d)

Electronics and connection compartment

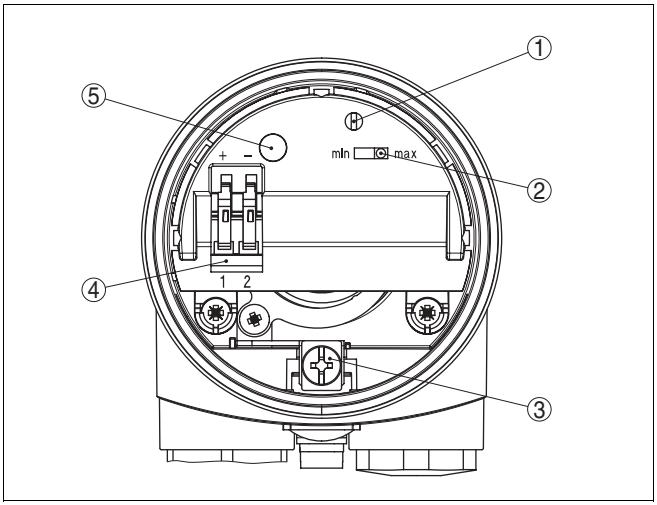

Fig. 9: Electronics and connection compartment
1 Potentiometer for switching point adaptation (covered)
2 DIL switch for mode adjustment
3 Ground terminal
4 Terminals
5 Control lamp

Wiring plan

For connection to a signal conditioning instrument. The sensor is powered via the connected signal conditioning instrument. For further information see the Technical data in the Supplement.

The wiring example is applicable for all suitable signal conditioning instruments.

If the mode switch of OPTISWITCH 3100 C is correctly set to "max", then the signal lamp on OPTISWITCH 3100 C lights

- red - with submerged vibrating element
- green - with uncovered vibrating element

Take note of the operating instructions manual of the signal conditioning instrument. Suitable signal conditioning instruments are listed under Technical data.

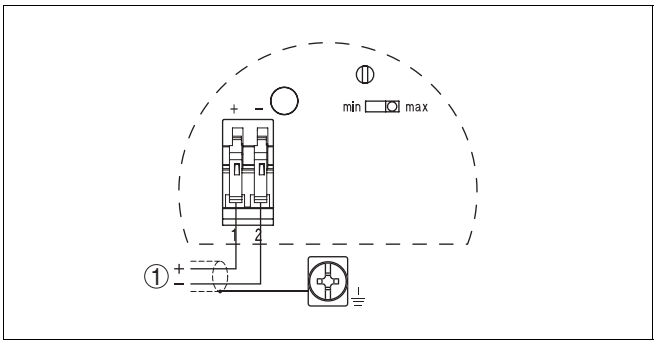

Fig. 10: Wiring plan
1 Voltage supply

6 Setup

6.1 General

The numbers in brackets refer to the following illustrations.

Function/Configuration

On the electronics module you will find the following indicating and adjustment elements:

- Potentiometer for switching point adaptation (1)
- DIL switch for mode adjustment - min./max. (2)
- Signal lamp (5)

Note:
As a rule, always set the mode with mode switch (2) before starting the setup of OPTISWITCH 3100 C. If the instrument is used in conjunction with a signal conditioning instrument, always set the mode switch (2) on OPTISWITCH 3100 C to max. mode.

The mode is selected on the signal conditioning instrument with the mode switch.

The switching output will change if you set one of the two mode switches afterwards. This could possibly trigger other connected instruments or devices.

6.2 Adjustment elements

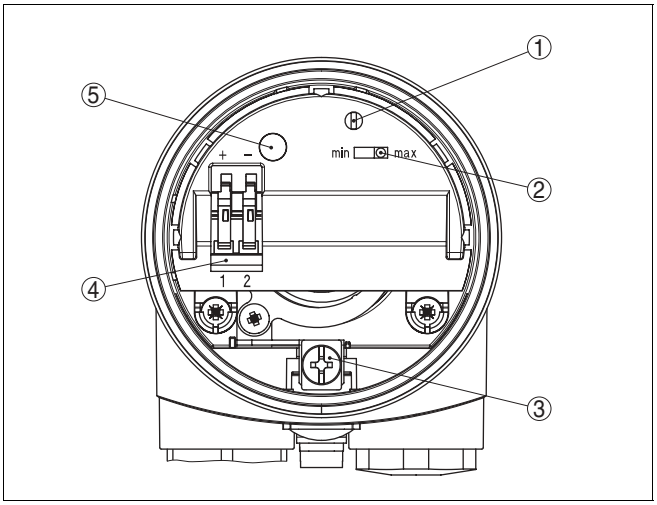

Fig. 11: Oscillator VB 60Z - Two-wire output
1 Potentiometer for switching point adaptation
2 DIL switch for mode adjustment
3 Ground terminal
4 Terminals
5 Control lamp

Switching point adaptation (1)

With the potentiometer you can adapt the switching point to the solid. It is already factory-preset and must be adjusted only in special cases.

By default, the potentiometer of OPTISWITCH 3100 C is set to mid position (>0.02 g/cm^3 or >0.0008 lbs/in^3). In case of very light-weight solids, you have to turn the potentiometer to the complete left position (>0.008 g/cm^3 or >0.0003 lbs/in^3). Hence the OPTISWITCH 3100 C will be more sensitive and can detect light-weight solids more reliably.

For instruments detecting solids in water, these values are not applicable. The potentiometer is preset and must not be changed.

Mode adjustment (2)

With the mode adjustment (min./max.) you can determine the output current.

When using a signal conditioning instrument, always set the mode switch to max. mode.

In this case you select the requested mode acc. to the "*Function chart*" (max. - max. detection or overfill protection,

min. - min.detection or dry run detection) on the signal conditioning instrument.

When used on a control system, the following values apply:

- min. mode
  - Vibrating element uncovered - 16 mA ±1 mA
  - Vibrating element covered - 8 mA ±1 mA
- max. mode
  - vibrating element uncovered - 8 mA ± 1 mA
  - vibrating element submerged - 16 mA ± 1 mA

Signal lamp (5)

Control lamp for indication of the switching condition.

- green = 8 mA
- red = 16 mA
- red (flashing) = Failure (<2.3 mA)

6.3 Function chart

OPTISWITCH 3100 C level sensor
The following chart provides an overview of the switching conditions depending on the adjusted mode and level.

Mode on the sensor	Level	Signal current - Sensor	Signal lamp sensor
max. Overfill protection		8 mA	 Green
max. Overfill protection		approx. 16 mA	 red
min. Dry run protection		approx. 8 mA	 Green
min. Dry run protection		approx. 16 mA	 red

Mode on the sensor	Level	Signal current - Sensor	Signal lamp sensor
Fault signal (min./max. mode)	any	<2.3 mA	flashes red

OPTISWITCH 3100 C level switch with signal conditioning instrument[1)]

The following chart provides an overview of the switching conditions depending on the adjusted mode of the signal conditioning instrument and the level.

Note:
Keep in mind that the mode switch of OPTISWITCH 3100 C must be always set to "max.".

Mode on the signal conditioning instrument	Level	Signal current - Sensor	Signal lamp sensor	Signal lamp, signal conditioning instrument
Mode A Overfill protection		approx. 8 mA	Green	
Mode A Overfill protection		approx. 16 mA	red	○
Mode B Dry run protection		approx. 16 mA	red	
Mode B Dry run protection		approx. 8 mA	Green	○
Fault signal (mode A/B)	any	<2.3 mA	flashes red	○

[1)] You will find suitable signal conditioning instruments in the Technical data

7 Maintenance and fault rectification

7.1 Maintenance

When used as directed in normal operation, OPTISWITCH 3100 C is completely maintenance-free.

7.2 Fault rectification

Checking the switching signal

? OPTISWITCH 3100 C signals "covered" when the vibrating element is not submerged (overfill protection)

? OPTISWITCH 3100 C signals "uncovered" when the vibrating element is submerged (dry run protection)

- Supply voltage too low

→ Check the power supply

- Electronics defective

→ Push the mode switch (min./max.). If the instrument then changes the mode, the instrument may be mechanically damaged. Should the switching function in the correct mode still be faulty, return the instrument for repair.

→ Push the mode switch. If the instrument then does not change the mode, the oscillator may be defective. Exchange the oscillator.

→ Check if there is buildup on the vibrating element, and if so, remove it.

- Unfavourable installation location

→ Mount the instrument at a location in the vessel where no dead zones or mounds can form.

→ Check if the vibrating element is covered by buildup on the socket.

- Wrong mode selected

→ Set the mode switch on OPTISWITCH 3100 C to "max". Set the correct mode on the signal conditioning instrument (A: overfill protection; B: dry run protection).

? Signal lamp flashes red

- Electronics has detected a failure

→ Exchange instrument or return it for repair

7.3 Exchanging the electronics

In general, all oscillators of series VB60 can be interchanged. If you want to use an oscillator with a different signal output, you can download the corresponding operating instructions manual from our homepage under Downloads.

With EExd instruments, the housing cover may only be opened if there is no explosive atmosphere present.

Proceed as follows:

1 Switch off power supply

2 Unscrew the housing cover

3 Lift the opening levers of the terminals with a screwdriver

4 Pull the connection cables out of the terminals

5 Loosen the two screws with a Phillips screwdriver (size 1)

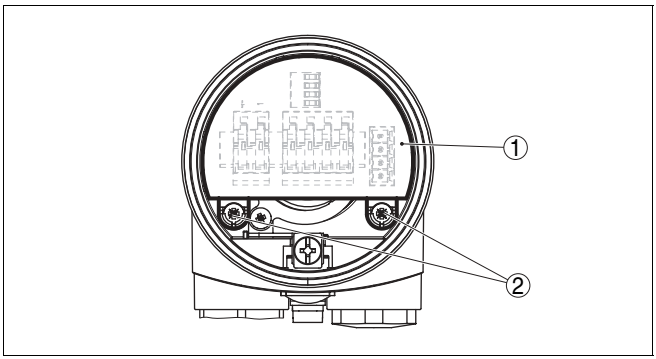

Fig. 12: Loosen the screws
1 Electronics module
2 Screws (2 pcs.)

6 Remove the old oscillator

7 Compare the new oscillator with the old one. The type label of the oscillator must correspond to that of the old oscillator. This applies particularly to instruments used in hazardous areas.

8 Compare the settings of the two oscillators. Set the adjustment elements of the new oscillator to the settings of the old oscillator.

Information:
Make sure that the housing is not rotated during the electronics exchange. Otherwise the plug may be in a different position later.

9 Insert the oscillator carefully. Make sure that the plug is in the correct position.

10 Screw in and tighten the two screws with a Phillips screwdriver.

11 Insert the wire ends into the open terminals according to the wiring plan

12 Close the opening levers of the terminals, you will hear the terminal spring closing

13 Check the hold of the wires in the terminals by lightly pulling on them

14 Check the tightness of the cable entry. The seal ring must completely encircle the cable.

15 Screw the housing cover back on

The electronics exchange is finished.

7.4 Instrument repair

If a repair is necessary, please proceed as follows:

You can download a return form from our Internet homepage http://www.krohne-mar.com/fileadmin/media-lounge/PDF-Download/Specimen_e.pdf.

By doing this you help us carry out the repair quickly and without having to call for additional information.

- Print and fill out one form per instrument
- Clean the instrument and pack it damage-proof
- Attach the completed form and possibly also a safety data sheet to the instrument

8 Dismounting

8.1 Dismounting steps

Warning:
Before dismounting, be aware of dangerous process conditions such as e.g. pressure in the vessel, high temperatures, corrosive or toxic products etc.

Take note of chapters "*Mounting*" and "*Connecting to power supply*" and carry out the listed steps in reverse order.

With Ex instruments, the housing cover may only be opened if there is no explosive atmosphere present.

8.2 Disposal

OPTISWITCH 3100 C consists of materials which can recycled by specialised recycling companies. We have purposely designed the electronic modules to be easily separable.

WEEE directive 2002/96/EG
This instrument is not subject to the WEEE directive 2002/96/EG and the respective national laws (in Germany, e.g. ElektroG). Pass the instrument directly on to a specialised recycling company and do not use the municipal collecting points. These may only be used for privately used products acc. to the WEEE directive.

Correct disposal avoids negative effects to persons and environment and ensures recycling of useful raw materials.

Materials: see "*Technical data*"

If you cannot dispose of the instrument properly, please contact us about disposal methods or return.

9 Functional safety

9.1 General

Validity

This safety manual applies to measuring systems consisting of OPTISWITCH 3100 C vibrating level switches and integrated oscillator VB60Z. The instrument corresponds to a subsystem of type B.

The sensor software must correspond at least to version 1.03 or higher.

Area of application

The measuring system can be used for level detection of powders and granules which meet the specific requirements of the safety technology, e.g.:

- Mode "max" for overfill protection
- Mode "min" for dry run protection

The measuring system is qualified in both modes to meet the following requirement degree acc. to IEC 61508-2:

- **SIL2** with architecture 1oo1D (single channel)
- **SIL3** with architecture 1oo2D (double-channel/redundant)

With a special factory setting, the measuring system is also suitable for detection of solids in water (see operating instructions manual).

Safety function

The safety function of this measuring system is the detection and signalling of the condition of the vibration element. The safe condition depends on the mode:

- In mode "max": condition "covered"
- In mode "min": condition "uncovered"

Relevant standards

- IEC 61508-1, -2, -4
  - Functional safety of electrical/electronic/programmable electronic systems

Safety requirements

The failure limit values for a safety function, depending on the SIL class (of IEC 61508-1, 7.6.2)

Safety integrity level	Low demand mode	High demand mode
SIL	PFD_{avg}	PFH
4	$>=10^{-5}$ up to $<10^{-4}$	$>=10^{-9}$ up to $<10^{-8}$
3	**$>=10^{-4}$ up to $<10^{-3}$**	**$>=10^{-8}$ up to $<10^{-7}$**
2	**$>=10^{-3}$ up to $<10^{-2}$**	**$>=10^{-7}$ up to $<10^{-6}$**
1	$>=10^{-2}$ up to $<10^{-1}$	$>=10^{-6}$ up to $<10^{-5}$

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Safety integrity of the hardware for safety-related subsystems of type B (IEC 61508-2, 7.4.3)

Safe failure fraction	**Hardware fault tolerance**		
SFF	**HFT = 0**	**HFT = 1**	**HFT = 2**
<60 %	not permitted	SIL1	SIL2
60 % up to <90 %	SIL1	SIL2	SIL3
90 % up to <99 %	**SIL2**	**SIL3**	(SIL4)
>=99 %	SIL3	(SIL4)	(SIL4)

9.2 Planning

General instructions and restrictions

- The measuring system must be used acc. to the application
- The application-specific limits must be maintained and the specifications not exceeded.
- Acc. to the specifications in the operating instructions manual, the current load of the output circuits must be within the limits.
- It must be used only in products to which the materials of the vibrating system are sufficiently chemically resistant.

Note the following items for use as dry run protection system:

- Avoid buildup on the vibrating system (possibly smaller proof test intervals)
- Avoid granulation size of the product > 15 mm

Assumptions

For the implementation of FMEDA (Failure Mode, Effects and Diagnostics Analysis) the following assumptions form the basis:

- Failure rates are constant, wear of the mechanical parts is not taken into account
- Failure rates of external power supplies are not included
- Multiple errors are not taken into account
- The average ambient temperature during the operating time is +40°C (+104°F)
- The environmental conditions correspond to an average industrial environment
- The service lift of the components is between 8 to 12 years (IEC 61508-2, 7.4.7.4, remark 3)
- The processing unit can interpret "fail low" and "fail high" failures as interferences and output a suitable fault signal

- The communication via the IIC bus interface is only used for default scaling and for service purposes.
- The repair time (exchange of the measuring system) after a fail-safe error is eight hours (MTTR = 8 h)
- In the mode with the lowest demand rate, the reaction time of a connected control and processing unit to dangerous detectable errors is max. 1 hour.

Low demand mode

If the demand rate is only once a year, then the measuring system can be used as safety-relevant subsystem in "*low demand mode*" (IEC 61508-4, 3.5.12).

If the ratio of the internal diagnostics test rate of the measuring system to the demand rate exceeds the value 100, the measuring system can be treated in the way it is executing a safety function in the mode with low demand rate (IEC 61508-2, 7.4.3.2.5).

Corresponding characteristics is the value PFD_{avg} (average Probability of dangerous Failure on Demand). It is dependent on the test interval T_{Proof} between the function tests of the protective function.

For number values see paragraph "*Safety-technical characteristics*".

High demand mode

If the "*low demand rate*" does not apply, the measuring system as safety-relevant part system in "*high demand mode*" should be used (IEC 61508-4, 3.5.12).

The fault tolerance time of the complete system must be higher than the sum of the reaction times or the diagnostics test periods of all components in the safety chain.

Corresponding characteristics is the value PFH (failure rate).

For number values see paragraph "*Safety-technical characteristics*".

Safe condition and fault description

A safe failure exists if the measuring system goes to the defined safe condition without being required by the process or the interference current outputs "Fail low" or "Fail high".

If the internal diagnostics system detects an error, a fault current of < 2.3 mA will be outputted.

A dangerous undetected failure exists if the measuring system switches neither to the defined safe condition, nor to failure mode when the process requires it.

Set the mode switch on the sensor to "max"

Use as overfill protection system	**Use as dry run protection system**	
Safe condition	**"covered"**	**"uncovered"**
Output current in safe condition	12.5 mA … 23.5 mA	2.3 mA … 11.5 mA
Error current "Fail Low"	< 2.3 mA	< 2.3 mA
Error current "Fail High"	> 23.5 mA	> 23.5 mA

Set the mode switch on the sensor to "min"

Use as overfill protection system	**Use as dry run protection system**	
Safe condition	**"covered"**	**"uncovered"**
Output current in safe condition	2.3 mA … 11.5 mA	12.5 mA … 23.5 mA
Error current "Fail Low"	< 2.3 mA	< 2.3 mA
Error current "Fail High"	> 23.5 mA	> 23.5 mA

Configuration of the processing unit

If the measuring system delivers output currents of < 2.3 mA (Fail Low) or > 23.5 mA (Fail High), this may indicate a failure.

The processing unit must therefore interpret such currents as failure and output a suitable fault signal.

If this is not the case, the appropriate shares of the failure rates must be assigned to the dangerous failures. Therefore the stated values in chapter "Safety-relevant characteristics" can deteriorate.

The processing unit must correspond to the SIL level of the measuring chain.

If a SU 501 (Ex) is used for evaluation, the mode switch on the sensor must be set to "max". The signal conditioning instrument SU 501 (Ex) must be operated acc. to the quiescent current principle (use closing contact of the relay).

9.3 Setup

Mounting and installation

The prevailing plant conditions influence the safety of the measuring system. For this reason, carefully observe the mounting and installation instructions in the operator's manual. It is especially important to make sure the mode setting (min./ max.) is correct.

9.4 Reaction during operation and in case of failure

- The adjustment elements must not be modified during operation.
- If modifications have to be made during operation, carefully observe the safety functions.
- Fault signals that may appear are described in the appropriate operating instructions manual.
- In case of detected failures or fault signals, the entire measuring system must be switched out of service and the process held in a safe condition by means of other measures.
- An electronics exchange is easily possible and described in the operating instructions manual.
- If due to the detected failure, the electronics or the complete sensor is exchanged, the manufacturer must be informed (incl. a fault description).

9.5 Recurring function test

The recurring function test serves to reveal potential dangerous errors that are otherwise not discernible. The function of the measuring system must be checked at adequate intervals.

The operator is responsible for choosing the type of test and the intervals in the stated time frame. The time frame depends on the PFD_{avg} value acc. to the chart and diagram in section "Safety-related characteristics".

In high demand rate, no recurring function test is arranged in IEC 61508. A proof of the functional efficiency is seen in the more frequent demand of the measuring system. In double channel architectures it is useful to proof the redundancy by recurring function tests in appropriate intervals.

The test must be carried out in a way that verifies the flawless operation of the safety functions in conjunction with all system components.

This is ensured by a controlled reaching of the response height during filling. If filling up to the response height is not possible, then a response of the measuring system must be triggered by a suitable simulation of the level or the physical effect.

The methods and procedures used during the tests must be stated and their suitability must be specified. The tests must be documented.

If the function test proves negative, the entire measuring system must be switched out of service and the process held in a safe condition by means of other measures.

In the double channel architecture 1oo2D this applies separately to both channels.

Recurring function test when using the measuring system as overfill protection

If the measuring system is used as overfill protection, the proof of the function is ensured by a simple function test which can be triggered and monitored manually or by a connected control system.

This function test is triggered by interrupting the supply cable for at least two seconds, then a switch on procedure follows as described in the operating instructions manual.

If the test is carried out this way, make sure that the vibrating element is not covered.

If the evaluation is made by a control system, the correct sequence of the current change must be checked and documented.

If a connected signal conditioning instrument is used for evaluation, the recurring function test can be carried out by simply pressing the test key on the signal conditioning instrument. You will find more details in the operating instructions manual of the signal conditioning instrument. Suitable signal conditioning instruments are listed under Technical data.

9.6 Safety-related characteristics

The failure rates of the electronics and the vibrating system were determined by an FMEDA acc. to IEC 61508. Basis for the calculations are component failure rates acc. to SN 29500. All values relate to an average ambient temperature of +40°C (+104°F) during operation. The calculations are further based on the instructions stated in chapter "Planning".

Overfill protection

Mode switch is set to "max"

λ_{sd}	49 FIT	safe detected failure (1 FIT = failure/10^9h)
λ_{su}	387 FIT	safe undetected failure
λ_{dd}	163 FIT	dangerous detected failure
λ_{du}	18 FIT	dangerous undetected failure
SFF	> 97 %	Safe Failure Fraction
DC_S	11 %	Diagnosis coverage $DC_S = \lambda_{sd}/(\lambda_{sd} + \lambda_{su})$
DC_D	90 %	Diagnosis coverage $DC_D = \lambda_{dd}/(\lambda_{dd} + \lambda_{du})$

Mode switch is set to "min"

λ_{sd}	39 FIT	safe detected failure
λ_{su}	373 FIT	safe undetected failure
λ_{dd}	168 FIT	dangerous detected failure
λ_{du}	36 FIT	dangerous undetected failure
SFF	> 94 %	Safe Failure Fraction
DC_S	9 %	Diagnosis coverage $DC_S = \lambda_{sd}/(\lambda_{sd} + \lambda_{su})$
DC_D	82 %	Diagnosis coverage $DC_D = \lambda_{dd}/(\lambda_{dd} + \lambda_{du})$

Dry run protection

Mode switch is set to "max"

λ_{sd}	39 FIT	safe detected failure
λ_{su}	352 FIT	safe undetected failure
λ_{dd}	182 FIT	dangerous detected failure
λ_{du}	43 FIT	dangerous undetected failure
SFF	> 93 %	Safe Failure Fraction
DC_S	10 %	Diagnosis coverage $DC_S = \lambda_{sd}/(\lambda_{sd} + \lambda_{su})$
DC_D	81 %	Diagnosis coverage $DC_D = \lambda_{dd}/(\lambda_{dd} + \lambda_{du})$

Mode switch is set to "min"

λ_{sd}	45 FIT	safe detected failure
λ_{su}	361 FIT	safe undetected failure
λ_{dd}	173 FIT	dangerous detected failure
λ_{du}	37 FIT	dangerous undetected failure
SFF	> 94 %	Safe Failure Fraction

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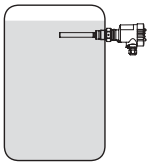
DC_S	11 %	Diagnosis coverage $DC_S = \lambda_{sd}/(\lambda_{sd} + \lambda_{su})$
DC_D	82 %	Diagnosis coverage $DC_D = \lambda_{dd}/(\lambda_{dd} + \lambda_{du})$

General data

$T_{Diagnosis}$ Diagnosis test period	100 sec
MTBF = MTTF + MTTR	1.59×10^6 h
max. useful life of the measuring system for the safety function	approx. 10 years

Single channel architecture

Architecture 1oo1D - Overfill protection



SIL2 (Safety Integrity Level)

HFT = 0 (Hardware Fault Tolerance)

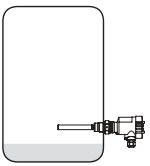
Mode switch is set to "max"

PFD_{avg} T_{Proof} = 1 year T_{Proof} = 5 years T_{Proof} = 10 years	 $< 0.008 \times 10^{-2}$ $< 0.039 \times 10^{-2}$ $< 0.077 \times 10^{-2}$
PFH [1/h]	$<1.8 \times 10^{-8}$/h

Mode switch is set to "min"

PFD_{avg} T_{Proof} = 1 year T_{Proof} = 5 years T_{Proof} = 10 years	 $< 0.016 \times 10^{-2}$ $< 0.078 \times 10^{-2}$ $< 0.156 \times 10^{-2}$
PFH [1/h]	$<3.6 \times 10^{-8}$/h

Architecture 1oo1D - Dry run protection



SIL2 (Safety Integrity Level)

HFT = 0 (Hardware Fault Tolerance)

Mode switch is set to "max"

PFD_{avg} T_{Proof} = 1 year T_{Proof} = 5 years T_{Proof} = 10 years	 $< 0.019 \times 10^{-2}$ $< 0.093 \times 10^{-2}$ $< 0.186 \times 10^{-2}$
PFH [1/h]	$< 4.3 \times 10^{-8}$/h

Mode switch is set to "min"

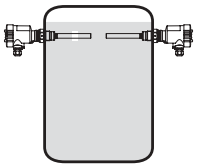
PFD_{avg} T_{Proof} = 1 year T_{Proof} = 5 years T_{Proof} = 10 years	 $< 0.016 \times 10^{-2}$ $< 0.081 \times 10^{-2}$ $< 0.162 \times 10^{-2}$
PFH [1/h]	$< 3.7 \times 10^{-8}$/h

Double channel architecture

Here you see an example how the measuring system in double channel architecture can be used in an application with demand rate SIL3. A Common Cause Factor of beta = 10 % (worst case) is taken into account.

If the instruments are used in another (multiple channel) architecture, the values must be calculated for the selected application by means of the above failure rates.

Architecture 1oo2D - Overfill protection



SIL3 (Safety Integrity Level)

HFT = 1 (Hardware Fault Tolerance)

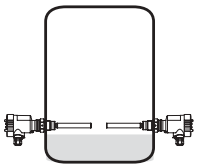
Mode switch is set to "max"

PFD_{avg} T_{Proof} = 1 year T_{Proof} = 5 years T_{Proof} = 10 years	 $< 0.007 \times 10^{-3}$ $< 0.036 \times 10^{-3}$ $< 0.073 \times 10^{-3}$
PFH [1/h]	$< 1.8 \times 10^{-8}$/h

Mode switch is set to "min"

PFD_{avg} T_{Proof} = 1 year T_{Proof} = 5 years T_{Proof} = 10 years	 $< 0.015 \times 10^{-3}$ $< 0.076 \times 10^{-3}$ $< 0.153 \times 10^{-3}$
PFH [1/h]	$< 2.0 \times 10^{-8}$/h

Architecture 1oo2D - Dry run protection



SIL3 (Safety Integrity Level)

HFT = 1 (Hardware Fault Tolerance)

Mode switch is set to "max"

PFD_{avg} T_{Proof} = 1 year T_{Proof} = 5 years T_{Proof} = 10 years	 $< 0.018 \times 10^{-3}$ $< 0.091 \times 10^{-3}$ $< 0.184 \times 10^{-3}$
PFH [1/h]	$< 2.3 \times 10^{-8}$/h

Mode switch is set to "min"

PFD_{avg} T_{Proof} = 1 year T_{Proof} = 5 years T_{Proof} = 10 years	 < 0.016 x 10^{-3} < 0.079 x 10^{-3} < 0.160 x 10^{-3}
PFH [1/h]	< 2.1 x 10^{-8}/h

Time-dependent process of PFD_{avg}

The time-dependent process of PFD_{avg} reacts in the time period up to 10 years virtually linear to the operating time. The above values only apply to the T_{Proof} interval, after which a recurring function test must be carried out.

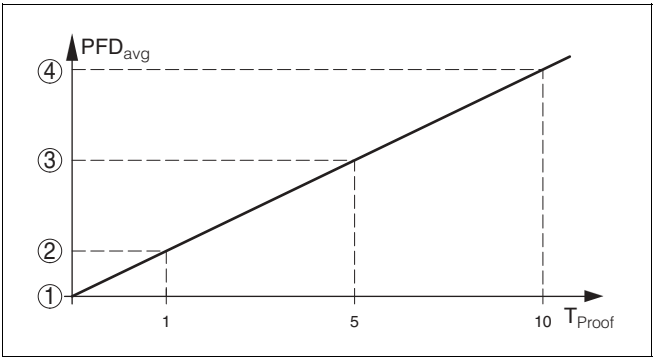


Fig. 13: Time-dependent process of PFD_{avg}[2)]
1 PFD_{avg} = 0
2 PFD_{avg} after 1 year
3 PFD_{avg} after 5 years
4 PFD_{avg} after 10 years

[2)] Numbers see in the above charts.

10 Supplement

10.1 Technical data

General data

Material 316L corresponds to 1.4404 or 1.4435

Materials, wetted parts	
– Process fitting - Thread	316L
– Process fitting - Flange	316L
– Process seal	Klingersil C-4400
– Tuning fork	316L
– Extension tube ø 43 mm (ø 1.7 in)	316L
Materials, non-wetted parts	
– Housing	plastic PBT (Polyester), Alu-die casting powder-coated, 316L
– Seal ring between housing and housing cover	NBR (stainless steel housing), silicone (Alu/plastic housing)
– Ground terminal	316L
Weights	
– with plastic housing	1500 g (53 oz)
– with Aluminium housing	1950 g (69 oz)
– with stainless steel housing	2300 g (81 oz)
Max. lateral load	600 N (135 lbf) longitudinal to the fork side

Output variable

Output	Two-wire output
Suitable signal conditioning instrument	SU 501 Ex
Output signal	
– min. mode	Vibrating element uncovered - 16 mA ±1 mA Vibrating element covered - 8 mA ±1 mA
– max. mode	Vibrating element uncovered - 8 mA ±1 mA Vibrating element covered - 16 mA ±1 mA
– Fault signal	<2.3 mA
Modes (adjustable)	min/max
Integration time	
– when immersed	approx. 0.5 s
– when laid bare	approx. 1 s

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Ambient conditions

Ambient temperature on the housing	-40 ... +80°C (-40 ... +176°F)
Storage and transport temperature	-40 ... +80°C (-40 ... +176°F)

Process conditions

Parameter	level of solids
Process pressure	-1 ... 16 bar/-100 ... 1600 kPa (-14.5 ... 232 psi)

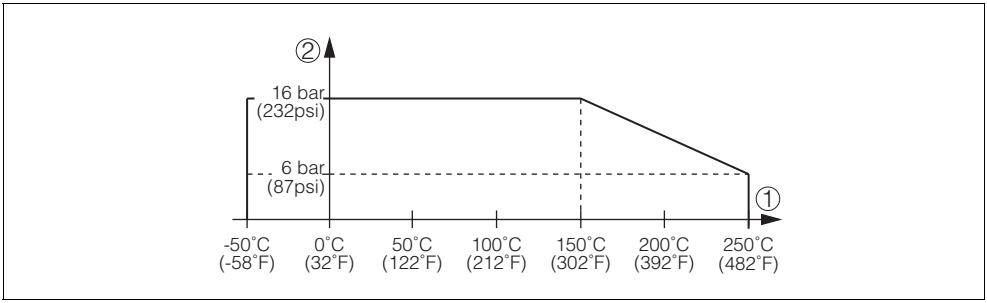


Fig. 14: Process pressure - Product temperature
1 Product temperature
2 Process pressure

OPTISWITCH 3100 C of 316L	-50 ... +150°C (-58 ... +302°F)
Process temperature (thread or flange temperature) with temperature adapter (option)	-50 ... +250°C (-58 ... +482°F)

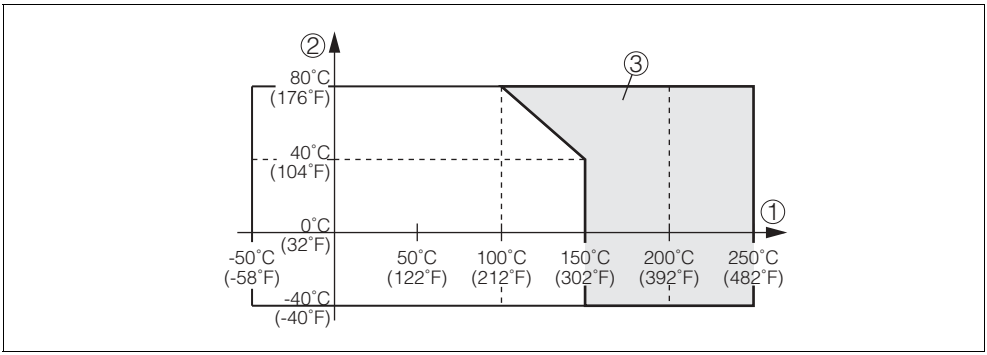


Fig. 15: Ambient temperature - Product temperature
1 Product temperature
2 Ambient temperature
3 Temperature range with temperature adapter

Density

– Standard	>0.02 g/cm³ (>0.0007 lbs/in³)
– adjustable	>0.008 g/cm³ (>0.0003 lbs/in³)

Electromechanical data

Cable entry/plug[3]	
– Single chamber housing	• 1x cable entry M20x1.5 (cable-ø 5 … 9 mm), 1x blind plug M20x1.5 or: • 1x closing cap ½ NPT, 1x blind plug ½ NPT or: • 1x plug (depending on the version), 1x blind plug M20x1.5
Spring-loaded terminals	for wire cross section up to 1.5 mm² (0.0023 in²)

Adjustment elements

Mode switch	
– min.	min. detection or dry run protection
– max.	max. detection or overfill protection

Voltage supply

Voltage supply	10 … 36 V DC (via the signal conditioning instrument)

Electrical protective measures

Protection	IP 66/IP 67
Overvoltage category	III
Protection class	II

Approvals[4]

ATEX II 1G, 1/2G, 2G EEx ia IIC T6[5]

ATEX II 1G, 1/2G, 2G EEx ia IIC T6 + ATEX II 1/2 D IP66 T

ATEX II 1/2G, 2G EEx d IIC T6

[3] Depending on the version M12x1, acc. to DIN 43650, Harting, Amphenol-Tuchel, 7/8" FF

[4] Deviating data with Ex applications: see separate safety instructions

[5] only in conjunction with electronics "Z"

ATEX II 1/2 D IP66 T [6)]

[6)] See temperature statements in the safety instructions manual

10.2 Dimensions

OPTISWITCH 3100 C[7)]

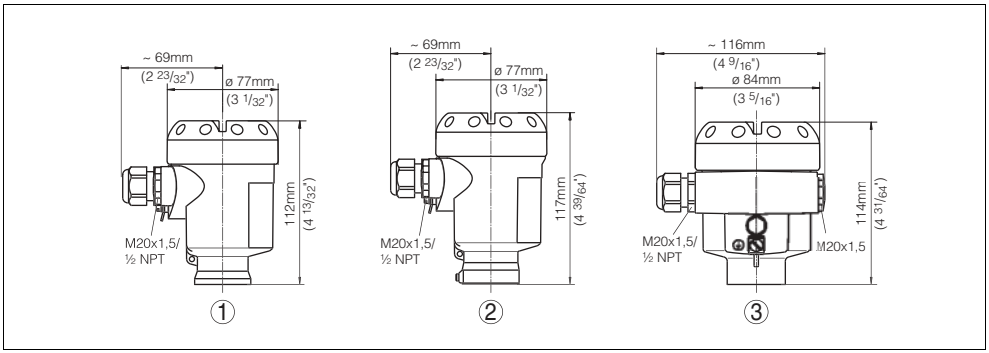


Fig. 16: Housing versions
1 Plastic housing
2 Stainless steel housing
3 Aluminium housing

7) All dimensions in mm (inch).

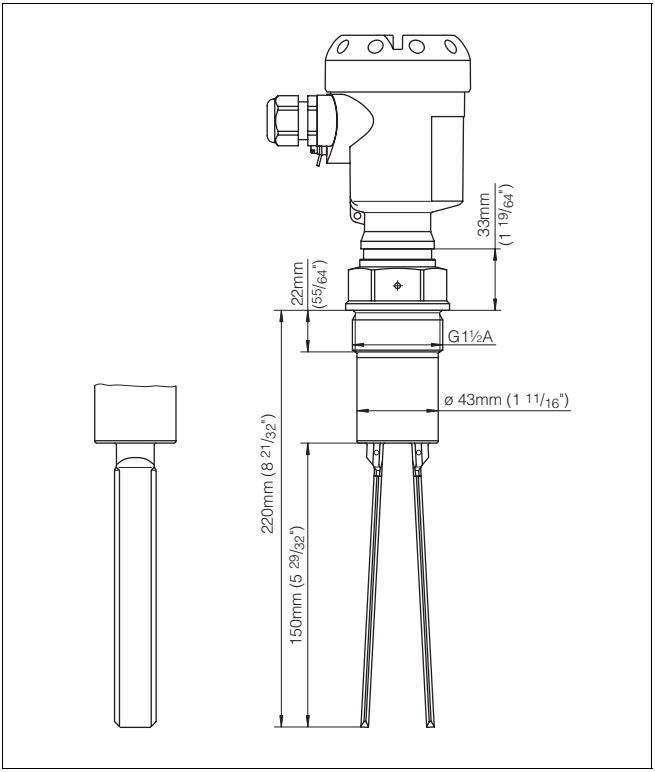


Fig. 17: OPTISWITCH 3100 C - Threaded version G1½A

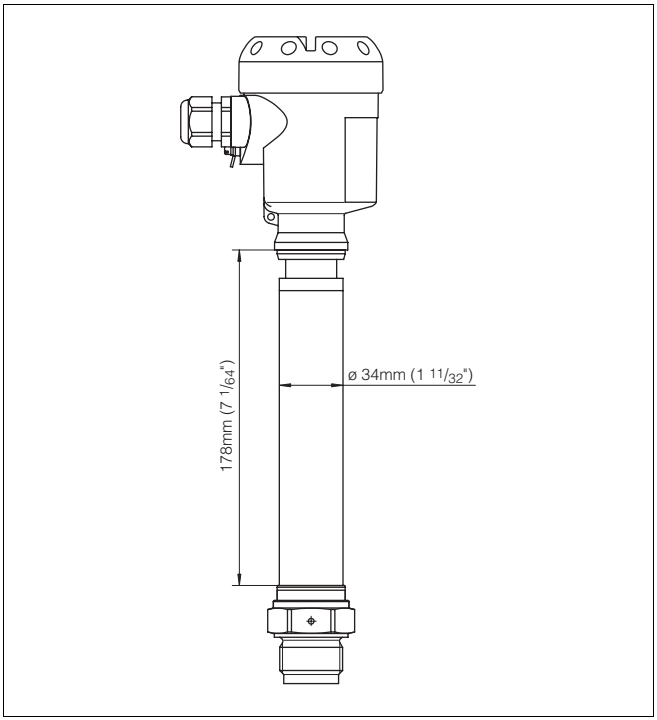


Fig. 18: Temperature adapter

10.3 Certificates

SIL declaration of conformity

KROHNE

Konformitätserklärung
declaration of conformity
Déclaration de conformité
IEC 61508 / IEC 61511

KROHNE S.A.S.
Les Ors
26103 ROMANS
France

erklärt als Hersteller, dass die Vibrationsgrenzschalter
declares as manufacturer, that the vibrating level switches
déclare en tant que fabricant que les détecteurs vibrants

OPTISWITCH 3100 C, 3200 C, 3300 C
mit / with / avec VB60C / ...R / ...T / ...N /...Z (Ex)

entsprechend der IEC 61508 für den Einsatz in sicherheitsinstrumentierten Systemen geeignet sind. Die Sicherheitstechnische Kennzahlen sowie die Sicherheitshinweise im Safety Manual sind zu beachten.
(siehe entsprechende Betriebsanleitung, Kapitel „Funktionale Sicherheit")

according to IEC 61508 are suitable for safety instrumented systems (SIS). The safety related characteristics as well as the instructions of the safety manual must be considered.
(see corresponding operating instruction, chapter "Functional Safety")

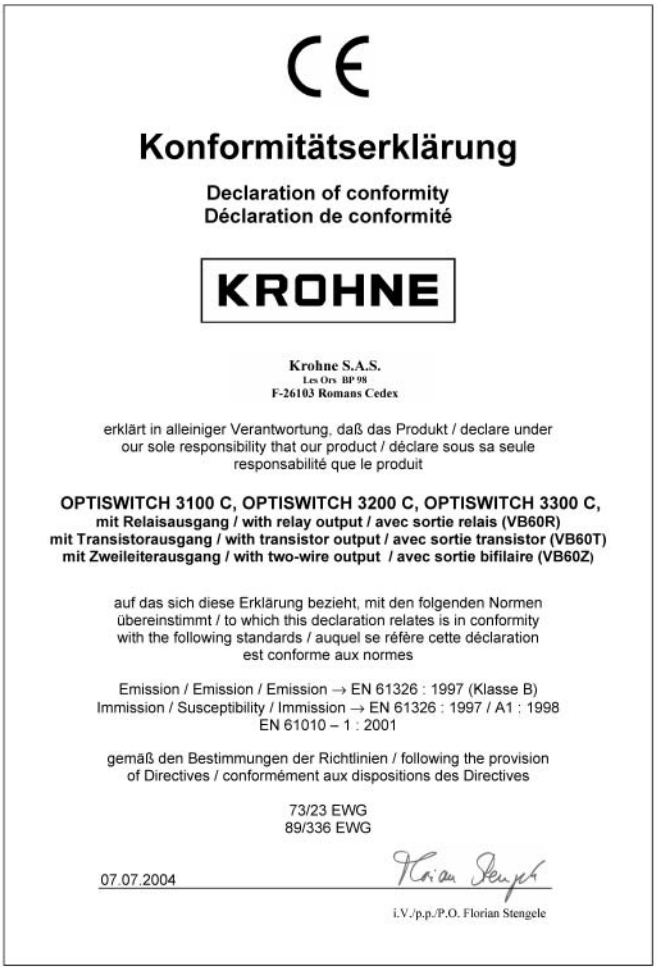
conviennent à une utilisation dans les systèmes de sécurité instrumentés suivant la norme IEC 61508. Les caractéristiques techniques relatives à la sécurité ainsi que les consignes de sécurité stipulées dans le Safety Manual sont à respecter.
(voir la notice technique de mise en service au chapitre „Sécurité fonctionnelle")

Romans, 21.10.2005
KROHNE S.A.S.

Dr. Florian Stengele
Geschäftsführer
Managing Director
Directeur général

Fig. 19: SIL declaration of conformity

CE declaration of conformity



CE

Konformitätserklärung

Declaration of conformity
Déclaration de conformité

KROHNE

Krohne S.A.S.
Les Ors BP 98
F-26103 Romans Cedex

erklärt in alleiniger Verantwortung, daß das Produkt / declare under our sole responsibility that our product / déclare sous sa seule responsabilité que le produit

OPTISWITCH 3100 C, OPTISWITCH 3200 C, OPTISWITCH 3300 C,
mit Relaisausgang / with relay output / avec sortie relais (VB60R)
mit Transistorausgang / with transistor output / avec sortie transistor (VB60T)
mit Zweileiterausgang / with two-wire output / avec sortie bifilaire (VB60Z)

auf das sich diese Erklärung bezieht, mit den folgenden Normen übereinstimmt / to which this declaration relates is in conformity with the following standards / auquel se réfère cette déclaration est conforme aux normes

Emission / Emission / Emission → EN 61326 : 1997 (Klasse B)
Immission / Susceptibility / Immission → EN 61326 : 1997 / A1 : 1998
EN 61010 – 1 : 2001

gemäß den Bestimmungen der Richtlinien / following the provision of Directives / conformément aux dispositions des Directives

73/23 EWG
89/336 EWG

07.07.2004

i.V./p.p./P.O. Florian Stengele

Fig. 20: CE declaration of conformity

Manufacturer declaration

KROHNE

Manufacturer declaration **no.** 24653

Messrs. Krohne S.A.S.
Les Ors BP 98
F-26103 Romans Cedex

declares that the **Compact vibrating level switch from types OPTISWITCH 3000 C, 3100 C, 3200 C, 3300 C with two-wire output**

in accordance with DIN/EN 60079-14/2004 paragraph 5.2.3 item c 1

and when used correctly under the condition that the operator follows the instructions in the documents listed:

- Mounting and operating instructions in the Operating Instructions manual
- Data and instructions of this manufacturer declaration
- Installation regulations

are suitable for use in Zone 2

The max. surface temperature increase* during operation is 40K.

With an ambient temperature of 70°C on the housing and a process temperature of 70°C, the max. surface temperature* is 110°C during operation.

Measures to maintain the explosion protection during operation:

- This declaration is only applicable if OPTISWITCH is operated within the stated electrical threshold values.
- Permissible operating voltages: 10...36V DC (via the signal conditioning instrument)
- The instrument must be installed and operated in such a way that no danger of ignition is expected due to electrostatic charge (depending of the version, the process fitting, the plastic coated probe part or the housing are made of electrically non-conductive plastic).
- The availability, the perfect quality and the correct position of the seal between the lower part of the housing and the cover must be ensured; the cover must be screwed on tightly.
- If the instrument is operated with open cover or if the switch/potentiometer is used, make sure that there is no explosive atmosphere.
- Make sure that the cable entry is tight and strain-relieved; the outer diameter of the connection cable must be adapted to the cable entry; the pressure screw of the cable entry must be tightened carefully.
- Free openings for cable and cable entries must be covered tightly.
- OPTISWITCH must be mounted in such a way that contact of the sensor to the vessel wall can be excluded by taking vessel installations and flow conditions in the vessel into account.
- The surface temperature must not exceed the ignition temperature of the concerned explosive atmosphere.

*Single component in the instrument

This instrument was judged by a person meeting the requirements acc. to DIN/EN 60079-14.

Krohne S.A.S.
Romans Cedex, den 31.05.05

i.V. Stengele

Fig. 21: Manufacturer declaration

29955-EN-060112

Subject to change without notice